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PATENT SPECIFICATION

616,777

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Complete Specification Accepted: Jan. 26, 1949.

(Under Section 6 (1) (a) of the Patents &c. (Emergency) Act, 1939 the proviso to Section 91 (4) of the Patents and Designs Acts, 1907 to 1946 became operative on Nov. 28, 1946.)

Index at acceptance:—**Class 35,** G(1c: 2b: 2i).

COMPLETE SPECIFICATION

Improvements in and relating to Electromagnets

We, THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, a British Company having its registered office at Crown House, Aldwych, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our invention relates to electromagnets of the type comprising a coil through which a plunger armature is adapted to pass. The object of the invention is to provide an electromagnet whose armature movement is substantially proportional to the current supplied to the exciting winding whereby a gradual movement of the armature may be obtained.

According to the present invention we provide an electromagnet of the kind set forth wherein the coil has a magnet core member provided with pole faces at opposite ends of the coil, the plunger armature being provided at each end thereof with corresponding peripheral pole faces, a support for each end of the armature being secured thereto and comprising a plurality of spring strips and means securing the ends of the strips to the core member so that the armature is supported by the spring strips centrally of the coil with the annular pole faces respectively in radial spaced relation with the annular pole faces on the core member and biased axially by the spring strips to an unattracted position.

In carrying out our invention in one form, we provide a plunger type armature for the magnet coil, which armature is mounted for movement without bearings. Thus each end of the plunger armature is secured to the centre of a disc of thin spring metal which has been cut away to form a plurality of narrow strips or spokes supporting each end of the armature. These spokes are arranged to bias the armature normally in an axially displaced unattracted position. Upon energization of the coil, the armature is moved against the bias force of the spokes to an attracted position, the movement of the armature being substantially proportional to the change in current in the coil.

For a more complete understanding of our invention, reference should be had to the accompanying drawing, Fig. 1 of which is a plan view partly in section showing the application of two electromagnets embodying our invention to the operation of a hydraulic valve; Fig. 2 is an enlarged view in perspective of a spring support for one end of the armature; Fig. 3 is an enlarged sectional view of an electromagnet embodying our invention taken along the line 3—3 of Fig. 4 looking in the direction of the arrows; while Fig. 4 is an end view of an electromagnet embodying our invention.

Referring to the drawing, we provide an operating coil 1 wound on a spool 2 of electrically insulating material with annular washer-shaped members 3 and 4 at its opposite ends joined by a ring 5 surrounding the coil, which parts form a support for the coil. Also, these parts are made of a magnetic material and form a magnetic circuit for the coil which is complete, except axially through the coil.

Extending axially through the coil, we provide a plunger armature comprising an outer tubular member 6 provided on its opposite ends with ridges or flanges 7 and 8, the cylindrical peripheral surfaces of which form pole faces with respect to the stationary pole faces constituted by the inner edges 9 and 10 of the members 3 and 4. The armature is mounted at each end on disc-like spider supporting members 11, 11*a*, one of which is shown in detail in Fig. 2. This member is constructed from a disc of thin non-magnetic spring metal of sufficient thickness to have the desired spring force, with three segmental sections cut away to leave three radially extending spring strips or spokes 12, 13, and 14 connecting hub portion 15

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Price 4s 6d

with the outer annular portion. For the purpose of increasing the resiliency of the spokes, each of them is provided with a substantially central arcuate bend indicated on the spoke 12 by the reference numeral 12*a*, the displacement of the bent portion being at right angles to the plane of the support 11. In a typical device the spider supports were made of phosphor bronze material .013" thick.

As shown in Fig. 3, the armature is secured at each end to the support by means of a tube 16 which extends through the member 6, both of which are made of magnetic material, and has each end extending through an aperture in the hub portion of the support 11 or 11*a*. A flange is provided on each end of the tube 16 on the outer side of the hub, whereby the hub is secured against the end of the member 6. This construction may be effected by providing a flange on one end only of the rod 16, assembling the parts and then upsetting the other end of the tube 16 to form the flange at that end.

The two spider supports 11 and 11*a* and the other parts are secured together by means of a plurality of bolts 17, six being shown, which bolts extend in parallel relation with the axis of the coil and through the ring members 3 and 4. Also, the bolts extend through an end cap member 18 enclosing one end of the solenoid and through a spacing ring 19 at the other end of the solenoid. In the construction shown, this spacing ring 19 is seated against a wall 20 of a supporting member provided with tapped holes into which the screws 17 extend, whereby the asesmbly is secured together and secured to the support 20.

As shown in Fig. 3, the annular pole flanges 7 and 8 are positioned on the plunger armature 6 so as to be biased by the spider supports axially toward the left hand to unattracted positions. Thus, when the coil is energized, a magnetic force is applied to the armature which moves the armature toward the right against the spring bias of the spider supports. The pole flanges 7 and 8 are moved to positions nearly opposite the pole faces 9 and 10 by maximum energization of the coil, this being the fully attracted position.

It will be understood that the magnetic force applied to the armature 6 in an axial direction toward the right would be zero if the armature were moved toward the right far enough to bring the pole flanges 7 and 8 exactly opposite the pole faces 9 and 10 or, in other words, in alignment with the pole faces 9 and 10. Therefore, the biasing forces applied by the spider supports prevent the armature from reaching this position of complete alignment. For a given excitation of the coil, the magnetic force applied to the armature decreases as the armature is moved toward this position of pole face alignment. As a result, the armature has a definite stable position for each value of coil excitation up to its final attracted position of near alignment of the pole faces.

This is a distinguishing characteristic of our electromagnet as contrasted, for example, with conventional solenoids such as those having a pivoted or plunger type armature in the operation of which the armature, when it starts to move toward its attracted position, the excitation being constant, is pulled with an increasing magnetic force. Such armatures obviously do not have a stable position for each value of excitation because when the excitation is made great enough to start movement of the armature against its biasing force, the increasing magnetic force moves the armature immediately to its fully attracted position.

As shown in Fig. 3, the armature 6 is positioned by the spider supports 11 and 11*a*, the coil being deenergized, in an unattracted position with the pole flanges 7 and 8 axially on the left-hand side of the pole faces 9 and 10. In this unattracted position, it will be understood that the spider supports assume their normal shapes and hold the armature in a position in which neither one exerts a spring bias on the armature, unless the armature is prevented from assuming that position, although movement of the armature toward the right hand to an attracted position is immediately opposed by the spring biasing forces of the spokes or arms of the spider supports tending to return the armature to the unattracted position shown in Fig. 3.

When the coil is energized, a magnetic force is applied to the armature in a direction to move it toward the right hand, this force varying with the excitation current supplied to the coil. The axial range of movement of the armature is relatively small, and the bends 12*a* in the spokes of the spider supports provide the necessary elongation of the spokes required for this movement. In the unattracted position of Fig. 3, the spokes have their minimum lengths, the hub 15 of each spider then lying in the plane of the peripheral ring portion of the spider. We have found that the armature movement is closely proportional to the current in the coil throughout its range of movement. Consequently, by suitably varying the current, a very small movement of the armature can be obtained between the un-

attracted and attracted positions. This proportional, or substantially straight line, relation between the movement of the armature and the current in the coil is, we have found, dependent to a considerable extent upon the bends $12a$ in the spider supports whereby the spokes are given greater resiliency.

An important feature of our invention in the provision of the substantially straight line current-displacement relation, is the elimination of all bearings for the armature with their inherent static friction which would tend to prevent movement of the armature in response to very small changes in the excitation current. The pole flanges 7 and 8 are sufficiently smaller than the pole faces 9 and 10 to provide for a predetermined radial clearance of air gap between them sufficient to neutralize the residual magnetism in the core parts after the coil has been deenergized. Another important feature is the elimination of any position of zero air for the armature with incidental sticking in such position.

We contemplate in one application of our invention, as shown in Fig. 1, the use of two electromagnets 21 and 22 constructed, as previously described, for operating jointly the plunger valve member 23 of a hydraulic valve 24. Thus the magnets 21 and 22 are mounted on a hydraulic valve casing with their armatures bearing respectively on opposite ends of the plunger member 23. To facilitate the adjustment of the armatures in engagement with the plunger, we provide each armature, as shown in Fig. 3 with a threaded bolt 25 extending through a longitudinal hole in the tube 16, which hole has a portion threaded and cooperating with the threads on the bolt 25. Thus by removing a cap 26 in the end cover 18, access is had to the left-hand or outer end of the bolt 25, which can be turned for longitudinal adjustment into engagement with the end of the plunger 23. It is secured in its adjusted position by a nut 27 and lock washer.

Preferably, as shown in Fig. 1, the adjustment of the two armatures is such that the plunger 23 is held in a central closed position, as shown, by the opposed biasing forces of the supporting spiders when the two electromagnets are deenergized. The adjustment bolts 25 are screwed against the opposite ends of the plunger 23 to apply a small amount of force to the plunger so that the supporting spiders are placed under some initial tension for positive positioning of the plunger 23 when the coils are deenergized. Thus energization of the magnet 21 moves the plunger 23 toward the right hand and energization of the magnet 22 moves it toward the left hand. Preferably, however, the two magnets are differentially energized so as to provide for a magnetic restoring force in addition to the spring bias of the spider supports. In other words, the two electromagnets would both be partially energized at the same time. When these energizations are equal, the armatures are in their unattracted positions into which they were moved by the combined spring bias of the spider supports and the opposing magnetic forces applied to the armatures as the energizations of the coils were equalized. Thus any force tending to displace the valve plunger 23, such as resulting from a heavy shock, is opposed not only by the spring biases but also by the magnetic forces. For movement of the plunger toward the right hand, as seen in Fig. 1, the energization in the magnet 21 is increased while the energization in the magnet 22 is decreased, and *vice versa*.

If the armature is held in a fixed position, it exerts a force which is proportional to the square of the current. The amount of force increase for a given current increase decreases as the saturation of the iron core of the electromagnet is approached. However, we contemplate that the electromagnet will be operated below the saturation point. The biasing force exerted by the spider supports, however, are not exactly proportional to the movement of the armature. In a typical installation, as shown in Fig. 1, it was found that with the two electromagnets excited to about one-half of their maximum values when the valve was in its central closed position shown, the movement of the valve was substantially proportional to the changes in the excitations of the electromagnets. In other words, the travel of the valve was nearly proportional to the difference in the excitations of the two coils.

As indicated in Figs. 1 and 3, the fluid of the valve 24 has access to the interiors of the electromagnets around the armatures and the spider supports. This construction is used in order to avoid the provision of seals between the valve and the electromagnets.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An electromagnet of the kind set forth wherein the coil has a magnet core member provided with pole faces at opposite ends of the coil, the plunger armature being provided at each end thereof with corresponding peripheral pole faces,

a support for each end of the armature being secured thereto and comprising a plurality of spring strips and means securing the ends of the strips to the core member so that the armature is supported by the spring strips centrally of the coil with the annular pole faces respectively in radial spaced relation with the annular pole faces on the core member and biased axially by the spring strips to an unattracted position.

2. An electromagnet as claimed in claim 1 in which the spring supporting members comprise spring strips secured to the armature and extending radially therefrom, each of the strips being provided with an arcuate bend giving it increased resiliency for axial movement of the armature when the coil is energized

3. An electromagnet as claimed in claim 1 in which the spring supporting members comprise a disc-like member of thin spring material having segmental portions cut away to form a plurality of flexible strips extending radially from a hub portion to an outer annular portion.

4. An electromagnet constructed substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 25th day of November, 1946.

A. S. CACHEMAILLE,
Crown House, Aldwych, London, W.C.2.
Agent for the Applicants.

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[This Drawing is a reproduction of the Original on a reduced scale.]

FIG. 1.

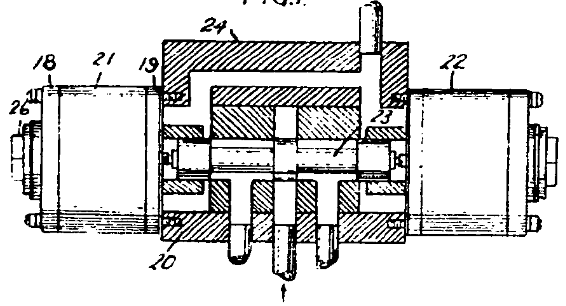


FIG. 2.

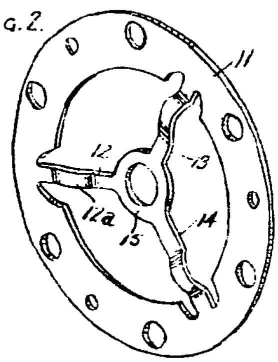


FIG. 3.

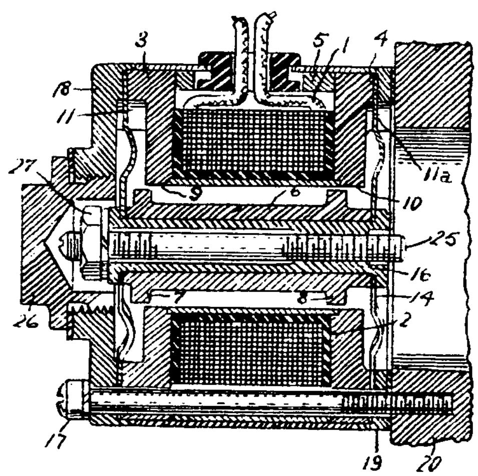
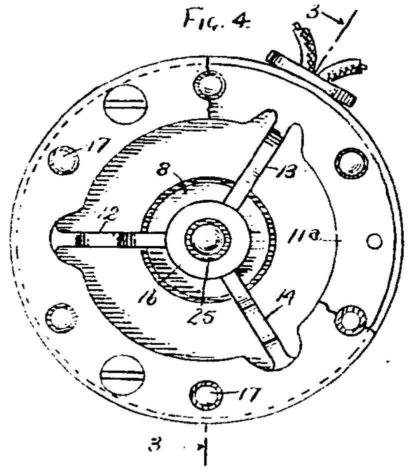


FIG. 4.



H.M.S.O. (Ty.P.)